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The attempt to utilize compressed air as a motive power for street cars in cities, appears to have been most unsuccessful. About four years since, a company was organized in New York city for the purpose of building street cars on the pneumatic system, capable of replacing those drawn by horse power, and about the early part of April, 1878, a passenger car propelled by compressed air was running on the Second avenue, New York, between 63d and 93d streets.

The experiment was considered perfectly satisfactory for a first attempt, as the cars performed their work admirably; and the public press and various eminent engineers considered the problem solved. There was, however, an essential element of success that was wanted, which appeared insignificant at the time, but which proved fatal to the whole scheme. This was a failure on the part of the engineers to design machinery which should be constant in its working, requiring little attention from the driver.

It was supposed that in building future composite pneumatic engine cars these defects could be remedied. But when the six cars built on this principle were placed on trial, the same trouble was experienced, and the experiment was abandoned, causing a considerable pecuniary loss to the promoters of the company.

The Pneumatic Tramway Engine Company, undaunted by past losses and failures, have renewed their efforts, and have recently constructed a pneumatic traction engine, which we understand will be immediately placed on trial on one of the New York elevated railroads. The successful working of Electric Railway Engines has probably increased the difficulties of those who are advocating the use of compressed air as a motive power. In the absence of smoke, odor, noise and cinders, both the electric and compressed air systems have many advantages over steam for elevated railroads, and the question of economy wiil probably decide which system shall be finally accepted. At the present moment all the advantages appear to be in favor of the electric railways for use within city limits, and it is probably a mere matter of time, for all the New York elevated railroads to be running their trains by this system.

THE STATE AND HIGHER EDUCATION.*

By PROFESSOR N. H. WINCHELL.

The incentive to the following address appears to have been certain remarks made officially by President John of Hamline University, who considered that "higher education should not be under the control of the State," and that the design of the State Colleges has been a conspicuous and universally acknowledged failure.

In the first part of the paper Professor Winchell presents an historical sketch of the circumstances, the result of which was "that the State finds itself in the conduct of systematic education."

After tracing the progress of education in Europe he states:

Thus we find that none of the old universities, except when under the control of the government, and sometimes not even then, have been willing to modify their curricula in compliance with the demands and spirit of the age. If they have done it, as more lately at Oxford University, it is only after the force of public sentiment has been able to batter down the walls of prejudice and conceit with which they have been surrounded. During this whole conflict throughout Europe the Church, in its various forms, but particularly the Roman church, instead of being the champion and refuge of free thought and free knowledge, has been the most powerful obstacle to its progress, and has persistently opposed every movement to introduce the means for disseminating useful knowledge among the people. The heat of the conflict is passed. The tide has set in the right direction. The old universities perceive the triumph of modern science. European governments are unanimously striving for the establishment of modern schools of science on the broadest foundations, and equipping them with the fullest appliances.

Now let us turn to America, and inquire how this history has been mirrored on our institutions of higher learning.

In the first place the church colleges that arose in this country prior to 1824, or even later, were modeled after the mediæval universities of Oxford and Cambridge, so far as they expanded into the dimensions of a university. For the most part they were simply colleges of classical lore, with but one course of study, aiming specifically. at first, to educate young men for the clerical profession. As they were born of the English universities, so they inherited their mediæval narrowness and bigotry. As the early church had grappled with Copernicus and Galileo, and had been worsted, so the later church would grapple with everything that bore a resemblance to or intimation of any new fangled notions of nature. Although the world had made wonderful strides in human knowledge, the colleges shut their eyes and ears to the change. The age demanded education in the great industries that characterize modern society, but could get only that of the age of Elizabeth. As modern science and civilization began to buzz about their doors, they drew themselves within their shells, affrighted, like snails. Having none of the elements of the

* Delivered before the Minnesota Academy of Natural Sciences, Jan. 12, 1881.

new light within them, they were literally enslaved to themselves and could not escape. They began to sink in public esteem. Their graduates failed conspicuously in competition in all the affairs of life with self-made men. Finally, in view of this disparity between the demand and supply of industrial and scientific instruction in America, a far-seeing and generous business man, Stephen Van Rensselaer by name, came forward with private means, and became the first to endow, in America, a "school of theoretical and applied science." This was done in 1824, and it is located at Troy, New York. Twenty years later the first voluntary effort was made within one of the old church colleges of America to regulate the curriculum so as to conform to the new demands, aud although pushed by one of the ablest educators of America, Francis Wayland, in his own institution, and with his own denomination, at Brown university, the movement ended in a conspicuous defeat of the "new education." After the successful establishment of the Troy Polytechnic Institute, the example of Van Rensselaer was followed in Connecticut by Joseph E. Sheffield in the founding of the Sheffield Scientific school, which became attached to, but by no means recognized as co-ordinate with, the old line course in Yale college. This was in 1860. In 1847, soon after the failure of Dr. Wayland at Brown University, Abbot Lawrence endowed the Lawrence Scientific school at Harvard college.

About this time the legislature of the new States of the West began to express the sentiments of the people. In Illinois conventions met in 1851 to consider such means as might be deemed expedient to further the interests of an agricultural community, and to take steps toward the establishment of an agricultural college. They met not as Presbyterians, or Methodists, or Romanists, but as an agricultural community. The next year petitions were sent to Congress for the endowment of industrial universities in each State. In 1850 the agricultural college of Michigan was provided for by the State constitution, and went into operation in 1855. The scientific course of the University of Michigan was ordered by the State legislature in 1851. In 1858 Iowa appropriated money for a model farm and an agricultural college. In Kentucky, under the guide of Regent Bowman, an institution, chartered in 1858, had been established for "diffusing education among the industrial classes." In Pennsylvania an agricultural college was established in 1854, and in Maryland in 1856. In New York, as early as 1837, a project for establishing an agricultural college at Albany was entered upon and a site was selected. This resulted in failure. It was revived in 1844, and again failed through the death of a liberal friend of the enterprise; but in 1856 the State Agricultural Society of New York induced the legislature to appropriate $40,000 for a college of agriculture. This institution was established at Ovid, and died when the war of the rebellion broke out in 1861. The People's College, at Havana, N. Y., intended entirely for the industrial classes, was at first offered the national agricultural land grant of New York State, but failing to comply with the conditions imposed by the legislature, this fund was passed to Cornell University at Ithaca. These institutions, all established prior to the year 1862, when Congress passed and the President approved the great educational land grant law had come into existence in compliance with the demands of modern civilization, and not at the instance of the church colleges, but often in the face of obstacles and discouragements thrown in their way by the church schools. But President John says that the "facilities of higher education existed in this country, and met all demands, before State colleges were thought of." With the single exception of Yale College and Hamline University at Red Wing, which established a so-called "Scientific Department," the former in 1846 and the latter in 1857, not one of the church colleges, so far as I have been able to learn, showed the first symptom of knowing, much less recognizing, the difference in educational need between the age of Bacon and that of Lincoln.

The soil, therefore, was all ready for the seed. The bill introduced by Mr. Morrill of Vermont was vetoed by conservative Buchanan. Passed again at the instance of Mr. Wade, with only seventeen opposing votes, it was signed by President Lincoln on the 2d of July, 1862. It has been said that times of war witness the birth of great ideas and the initiation of great enterprises. It is true that in the United States, with the establishment, through rivers of blood, of the national idea, was also established the idea of higher education by the State as one of the justifiable means, in a republic, of self-defence and self-perpetuation.

This is all passed now, nearly two decades ago. If we proceed to inquire what has been its effect, we shall be able to answer another of President John's surprising statements. Is the design of the law establishing these industrial colleges by Congress, "a conspicuous and universally acknowledged failure?"

One of the first effects of this land grant by Congress was an awakening in the church colleges, then existing, to the value of the public domain as an educational agency. This was so rapid, and so great, that some of them succeeded in capturing the whole fund almost before the people knew it had been given to them. In others, along with a compliance with the terms of the act, the State demanded representation on the controlling board; but in most cases the church colleges were passed by, and new institutions were founded by the various States, though still, in many cases, combined with some other State or private fund.

In the second place, this law, which has so positively been pronounced a failure, brought into existence up to 1876, about forty schools of agriculture and mechanic arts, often styled national schools of science. These have come into existence since 1862—except in three States where similar institutions had already been endowed by State funds. In some cases also the fund was applied by the State legislatures to rejuvenate weakly scientific institutions, or further endow those that were flourishing. In the meantime, since 1862, the various churches of the United States had founded, up to 1876, 106 denominational schools. Some of these are based on broad foundations, and, like Hamline University, offer the student the most complete scientific as well as classical and literary culture. While the national schools of science are mainly confined to their own sphere—the primary intent of the law creating them—the new church schools cover all the fields of knowledge. It cannot certainly be unjust to them to compare their patronage by the youth of the country, with that received by the State schools. This, perhaps, will throw some light on the question of their asserted failure.

The 106 denominational colleges, established between 1862 and 1876, both inclusive, as reported by the Commissioner of Education, are found to be giving instruction to 13,757 students, including all departments, preparatory and undergraduate, in all branches of knowledge, from theology to chemistry and engineering, giving them an average of 130 students for each institution. Of these students, 9,066 are reported as in the preparatory (or secondary) grade of study, an average of 85 for each institution; and 4,691 are reported in undergraduate studies—an average of 44 for each institution.

Taking the same authority for the statistics of the forty State schools of agriculture and mechanic arts, and including only those students that are strictly in those departments, wherever a pre-existing college received the congressional grant, we find 4,891 students, which gives an average of 122 for each institution. Of these, 631 are reported in preparatory (or secondary) courses, and 4,260 in the undergraduate courses of study. This gives the state schools an average of 16 in the prepara-

tory classes and 106 in the higher classes. Thus it can be seen that, as institutions of higher learning, the attendance on the new church colleges is but 41 per cent of that on the State colleges. Hence, if the law of congress which called into existence these State colleges be a failure, how much greater the failure of that sectarian spirit which called these 106 denominational colleges into existence.

Another remarkable effect of this movement toward popularizing higher education in America was the renovation and elevation of the church colleges, then existing, and the establishment of numerous others with much broader and a more liberal scope of instruction. This of itself has resulted in immense benefit to education, as well as to the church in America. This effect is as important as the creation of the State schools themselves. The church has always been the principal agent of higher education, at least in the United States, and the recognition, by these institutions, of the great underlying truths of nature, and of the ministration of her laws to the daily comfort of man, is an epoch in the history of the nineteenth century, which, in its effects on the race, will exceed all other achievements of the "new education." It will contribute not only to the spread of science, but also to the spread of Christianity, particularly among those intelligent classes of the people who have been hostile to it, or indifferent, because of the attitude of the Christian church toward the truths of modern science. If the church once recognizes the fact that every enlightened nation is in arms against its supine adherence to mediæval education, and condescends to place itself in harmony with the truths of creation as well as revelation, one of the greatest obstacles to the evangelization of the world will be removed. It is easy to see that the material aspects of modern civilization are rapidly penetrating unchristian and uncivilized nations, outstripping the church in evangelizing them. How much better it would be if the two agencies could go harmoniously together into the same field, co-operating to accomplish the same end.

What has been said, so far, relates to the past. A few matters of fact have been stated. They pertain to the title, by which the State received, and holds, the educational structure which she has occupied. But President John not only disputes the title, but also the right of the State to occupy this field. We admit that force does not always coincide with right, and that, although nine points in the law are established when peaceful possession is proven, the tenth point may have the right on its side. Let us enquire, then, if there be a consistent reasonableness in the State's attempting and continuing to do this work. We shall not attempt here the justification of the State in establishing and maintaining primary and secondary schools. It is not demanded. In passing, however, we will except President John's definition of the duty of the State to educate. He fixes it at the "limit of necessity to preserve its own existence." So let it be. We shall recur to it again. But, specifically, as relates to higher education, the leading objections that have been urged are the following: (1) The personality of the State. President Elliot has fully presented this objection. It is foreign to the free spirit of American republicanism to witness the controlling influence and authority of the State in social and educational affairs. It smacks of the divine right of kings, and is a reminder of the despotism of Europe, two centuries ago. Now all this may be an objection in monarchical governments, but it seems rather strange that any promising educator in republican America should forget that here the people are the State. There is no kingly personality interfering with the domestic and social institutions of the community. The authority that controls is the aggregate will of the community. The chief right of the State's power is to conserve this aggregate will. Such an expression of the will of the people is voluntaryism in the discharge of its highest organic function, and is not "paternal government." (2) Again it is objected to State education, that it tends to uniformity, and not to variety, reducing all pupils to the same pattern, and smothering the aspirations of genius which spurns conventionalities and revels in the gratification of its own idiosyncrasies. This objection is more valid in the lower schools than in the higher. In the higher schools it is very questionable if the institutions of the church would be as lenient with idiosyncrasies in pupils, as those of the State. Judging from the past it would be folly for a student with an idiosyncrasy of genius to flee to a church college for its indulgence. We cannot see how this objection applies more fully in State colleges than to church colleges. In fact it is one of the necessary sacrifices which an individual has to make, when he becomes one of an organized community. He receives the benefits of combined effort in all directions, and he has to surrender the personal freedom to act in certain directions in which his action would transgress the aggregate good of the community. The schools are for the average pupil—both State schools and church schools—and he with an idiosyncrasy will look in vain for a place to disport himself. (3). It is urged again that it is not economical. Because, forsooth, a sectarian zeal demands denominational colleges, and "cannot conscientiously accept this service of the State," and will maintain colleges of its own, therefore the State cannot rightfully duplicate these institutions and tax the denominations for their maintenance. Not to mention the brevity of the time elapsed since the sects were willing to "do the same kind of work" as the State University, it is enough to reply that this argument applies against all State organization for education. The Roman Catholic insists on maintaining his own hospitals, and objects to taxation for public schools. The Atheist opposes the public tax because in these schools is taught the idea of a God, the Jew because the New Testament is read, or the Protestant because it is not. This argument against the public schools may be applied with equal reason against the State's management of the deaf and mute. At least, certain medical fraternities might use it because they cannot "conscientiously" endorse nor accept the methods of treatment practised by the State. (4). But the fourth objection, after all, is the chief one urged by the opponents of State schools—they do not correctly indoctrinate the student in matters of religious dogma. It is said that "the State by self-imitation cannot teach religion." This assertion the State accepts, and would fain leave it to the proper agent, yet the State is not therefore "prohibited by statutory limitation from throwing the least safeguard around the minds of our youth," which is one of the surprising inferences of President John. The State in its educational operations will always be governed by the aggregate sentiment of the people. Those fundamental ideas of religion, which are accepted by all sects, the State institutions will be compelled to teach. If, peradventure, for a time they happen to lapse from this high duty, the will of the community will sooner or later be restored. They are creatures of the people. They will teach what the people can agree on shall be taught. While they must not teach sectarian dogma, they must not become centres of atheism nor of infidelity. If they did either, they would not long survive. Like the schools of Switzerland, they are based on the "principles of Christianity and democracy." The special, political and denominational application of these broad platforms is left to party politics, and to various sects.

We venture the assertion, however, that when the true kernel of this objection is found, it will not consist in a fear of the non-inculcation of these truths by the State, but in a jealousy of the sects, one against the other. Education by the church has been considered essentially the training of the youth and doctrines of the

catechism. Though greatly extended in scope, it is still animated by the same cardinal principle. Each sect must defend itself by teaching its own dogmas to the youth, and, though every State college were to be abolished, there would be still as great a reason for maintaining all the denominational colleges. How long it would be before they would degenerate to the condition of mere sectarian propaganda, as before the revival, no one can say, but there would be a strong tendency in that direction. Freed from the competition of State colleges, their zeal in the teaching of science would soon lag. Not having ready access to the public means and resources of instruction, such as the State archives, maps, authorities, explorations, surveys, statistics, and to the avenues by which the State knows and readily regulates the great industries of the people, the church colleges would very soon see that there is an actual incongruity in their assuming to direct the scientific and industrial education of the people. It is the chief business of the church to look after the spiritual well-being of the people and not to fit them to carry forward the complicated machinery of modern civilization. Religion is the lubricator of this vast system, and the church is the agent by which it is applied. When the church departs from this sphere, she forsakes the true idea of the primitive church. When she leaves her spiritual kingdom and assumes to direct in the construction of steam engines, in the handling of theodolites and compasses, in the management of cotton-gins, in the measurement of the angles of crystals, and the distances to the stars, she may very reasonably be held to be out of her sphere. She has the privilege, of course, of doing all these things, and there was a time when she had good reason to do them, and was urged to do them, as the only capable agent; but that time has passed, and it can hardly be considered to be her duty to do them in the nineteenth century, when other agents equally capable have arisen, endowed with that special duty and function.

One of the boasted advanced steps of the nineteenth century is the separation of the church and State. In the mere manipulation of the governmental machine this is fully realized in the United States, and in much of continental Europe. But the administration of the laws is not the State, nor, indeed, is the making up of the laws, nor both of these united. True statesmanship surveys the whole body politic. It foresees and often institutes national enterprises. It watches the external and also the internal influences that move the masses; it takes advantage of the shifting markets for the domestic products. It notes the rise and decline of the various industries. It applies stimulants when needed and repression when necessary. In short, the State is an all-prevading, energizing, regulating, far-seeing organization of the people; the culminating expression of the modern democracy. It is this machinery, which in our day is very closely connected with the appliances of modern science, which is not free from the church, but which the church assumes still to direct. Instead, we claim that it is the right and duty of the State itself to look after its own interests, and especially its highest interests, and to take measures to qualify citizens not only to read their ballots, but to discharge all the duties of high citizenship. There is no limit to this duty short of the necessity of the State, as has already been admitted. That which constitutes a State—"high-minded men"—is its necessity, and that it is the duty of the State to provide, to the end that its multifarious industry may be under the guide of the highest statesmanship.

THE French Government has appointed a committee, presided over by Rear Admiral Bourgeois, to study the different applications of electricity to navigation.

THE Society of Telegraph Engineers and Electricians will hold a meeting in Paris on September 21.

MAGIC MIRRORS*.

BY M. BERTIN.

[Translated from the French by Marchioness Clara Lanza.]

LADIES AND GENTLEMEN:—The term Magic was formerly applied to those metallic mirrors employed by sorcerers, necromancers, astrologers and charlatans, and by means of which spirits were invoked and the future predicted. These mirrors, transmitted from antiquity to the middle ages, were used to a very great extent about the sixteenth century, and up to two hundred years ago they were constantly seen in Europe. Now they are found nowhere except in the far East. We are able to furnish any amount of information about this strange superstition, but it is not of these mirrors that I intend to speak.

There is another kind of magic mirror, so-called because it produces effects apparently marvelous but real. History will tell you nothing, however, about these mirrors, and they are not even mentioned in any book of physics. Their appearance in Europe is quite recent, and as they are exceedingly rare, there is not often an opportunity presented for observing them. It is of this scientific curiosity that I shall talk to you this evening.

These mirrors are an uncommon variety of metallic ones. The latter you know were the first invented by man. The Greeks and Romans had no other kind, except a few specimens of glass mirrors made at the factory in Sidon. But glass when not quicksilvered does not make a good mirror, and it was not until the thirteenth century that quicksilver was employed for the purpose. Up to that date metallic mirrors alone were used, and even now some uncivilized nations employ and mannfacture no other kind.

The Chinese and Japanese, for instance, are an example†. Since they have been in constant communication with European nations, however, they have partially adopted our glass mirrors and send us their metal ones as objects of curiosity. Chinese mirrors are exceedingly rare, so rare, in fact, that there is not one to be had in Paris. This leads me to think that they are no longer manufactured. Japanese mirrors, on the contrary, are very common. This is perhaps owing to the fact that in Japan the mirror is not only a necessary article for the toilet, but also an object of national worship. The primitive religion of the country, which is still embraced by the aristocracy and called *Synthism*, worships the goddess of the sun as its principal divinity, and the Emperors of the nation are supposed to be her descendants. This goddess invented the metallic mirror, and presenting it to her son bade him preserve it religiously. In the palace of Mikado, therefore, the mirror chamber is as carefully attended to as that of the Emperor himself, and often receives greater attention. In the temples of *Synthism* the only object of worship is a mirror, kept in a box covered with several wrappings of silk. Although this religion has been abandoned by the greater portion of the people, who have since become Buddhists, the mirror, nevertheless, has always remained a precious article. The ladies keep it raised upon a tall easel, which brings the glass upon a level with their eyes when they stand upon tip-toe. When they wish to remove it they hold it carefully by the handle, sometimes thrusting the latter into a piece of split bamboo.

These mirrors are of bronze of various sizes and shapes, but always portable. One side is polished and amalgamated. It is also generally convex, so that the images reflected look somewhat distorted. The other side is flat or slightly concave and is always ornamented by figures

* Alecture delivered before the *Association Scientifique de France*.

† This statement is not altogether correct. The Chinese manufacture glass mirrors, and very seldom, if ever, use metallic ones any more.

in relief of more or less perfect workmanship. Japanese mirrors usually are more beautiful than the Chinese.

Here, gentlemen, are a few. I cannot pass them among you, but I can show them to you perfectly well by means of the magic lantern. This one is the copy of a mirror brought from Japan by Professor Dybowski. This second one belongs to General Teissier. The designs are of the reverse or unpolished side.

Among these mirrors there are a few of a lesser thickness, which possess a remarkable property. Although they reflect ordinary images in a diffused light, if a ray of sunlight falls across the polished surface and is reflected upon a white screen, the ornamentation upon the reverse side will be transported to the screen. This is what we call a magic mirror.

The first that appeared in Europe came from China. The Chinese, in fact, have known of them for a very long time. One of their historians who flourished in the eleventh century of our era, mentions them with admiration. Another writer, who lived in the year 1300, gave us a supposed explanation of the phenomenon. The Chinese Encyclopedia contains an article upon the subject, which has been translated by our great sinologue, Stanislas Julien. These mirrors have always been rare, but persons who have lived in China assure me that they can sometimes be found in Chinese curiosity shops.

We are not sure that the mirrors were ever purposely made. It is probable, on the contrary, that they are merely the result of imperfect fabrication. In regard to the Japanese this is absolutely certain, for magic mirrors are unknown in Japan. Neither the manufacturer nor the person who sells them has any idea of their peculiar property. European *savants*, however, have found magic mirrors from Japan many times. In 1832 M. Prinsep described one in the *Journal de la Société Asiatique*, which he had discovered in Calcutta. In 1877 Mr. Atkinson, Professor in the Imperial University of Jeddo, observed that numbers of Japanese mirrors produced magical effects. This attracted the attention of M. Ayrton, Professor in the Engineering School in the same city, who immediately began to investigate the matter. After examining five or six hundred he affirmed that three or four out of every hundred were magic.

Partially magic mirrors ought to be very common, and I am quite sure if I had been permitted to examine the Japanese collections in Paris, I should have found several. I am indebted to General Teissier for two beautiful mirrors that he brought from Japan. One of them is decidedly magic. I will have an electric light thrown across it and then upon the screen. You will see a part of the design upon the back appear.

Although we can furnish no written testimony concerning these mirrors, several learned men however, especially those who had traveled extensively, knew all about them. In the year 1830 Humboldt came all the way from Berlin to Paris, in order to show the Academy of Sciences a mirror which he believed to be magic. The experiments were made at the Observatory. Unfortunately there are no traces of them to be found in the scientific reviews of the period, but we know that the whole affair was a *fiasco*. Our illustrious chemist, M. Dumas, who was one of the investigators, affirms that Humboldt's mirror could not be considered magic in any sense of the word.

The first magic mirror that appeared in Europe was owned by M. Monchez, the Director of the Observatory in Paris. On his return from China he brought with him several mirrors, one of which was magic and had been sold as such. This mirror was presented to the Academy of Sciences on the 22d of July, 1844.

In 1847 a second one appeared belonging to the collection of the Marquis de la Grange. Stanislas Julien gave a detailed description of this one, in which he stated that the reflection obtained was identical with the reverse of the mirror, but that the latter was not in relief. This mirror, therefore, should not have been magic at all, or if it was, all our modern theory would be upset. Many attempts have been made to find this mirror, but up to the present time the search has proved fruitless.

A third magic mirror was presented to the Academy in 1847 by Person, Professor of Physics in Besançon. Person's report consists of twenty-five lines only, but it is extremely important, as it contains the whole theory of magic mirrors, which, until then was unknown.

Finally, in 1853, Maillard presented the Academy with a fourth mirror, which was not magic to any great extent. It is now in the Collège de France. I have held it in my hands, examined it carefully, and I can assure you that it is an exceedingly bad specimen. A great deal of imagination must be possessed by any person who can call the effects of this mirror magic.

This, gentlemen, was the last, and the excitement about magic mirrors began gradually to subside. Nothing more was heard of them till the year 1878, when MM. Ayrton and Perry, both professors in the Engineering School, at Jeddo, presented the Royal Society of London with several magic mirrors which they had brought from Japan. For the first time, technical observations were made concerning the construction of these mirrors. As to the mirrors themselves, the effects produced by them were truly marvellous. We were unable, however, to form any correct judgment upon them until last year, when M. Ayrton brought four to Paris. The experiments made by him proved very successful, and were witnessed by me with great interest.

Since then, the fame of magic mirrors has revived with double intensity.

A few days after M. Ayrton's séance I received a visit from my old pupil M. Dybowski, Fellow of the Academy of Physical Science, who returned from Japan after a professorship of more than two years at the University of Jeddo. Of course, you all know that after the revolution of 1869, Mikado's government founded large scientific schools in the capital. Unfortunately, they no longer "import" professors from Europe, but content themselves with such pupils as we turn out.

Like all Japanese, M. Dybowski was ignorant of the existence of magic mirrors. He brought with him, however, as curiosities, four mirrors of antique manufacture, which are called *Temple mirrors* in Japan, and considered to be superior to modern ones, as the fabrication has grown exceedingly defective of late, owing, probably, to the competition of European mirrors. We experimented together with these four specimens, one of which was found to be magic in a slight degree. This mirror has been the starting-point of all our subsequent progress. Of course, this was naturally the consequence of a sound theory, which, however, was not immediately established.

The oldest on record is that given by a Chinese author of the thirteenth century. According to him, "the cause of the phenomenon is due to the use of fine and coarse copper. If, in manufacturing the mirror, the image of a dragon is produced in relief upon the reverse, a similar dragon is engraved upon the polished side. This last is concealed by filling up the lines of the engraving with copper. The metal is then incorporated with a purer quality of copper, while the mirror is submitted to the action of fire. Finally, the surface is polished and washed over with amalgam." The author, however, does not seem to see that if the difference in the reflective power of the two qualities of copper was sensible enough to make the phenomenon appear, this variation must necessarily disappear under the application of the amalgam.

Brewster's theory does not differ notably from the Chinese explanation. He says the polishing effaces the engraving and renders it invisible in a diffused light, leaving upon the metal, however, variations of density and reflective power, which makes the image quite visible

when exposed to the sun. But Brewster was not aware that the surface of the mirrors was amalgamated, and we may safely say that he was wrong to attempt a solution of the mystery, without ever having seen a magic mirror.

Nevertheless, before rejecting his idea completely, let us seek to verify it. I myself have had an engraving made upon copper, then caused it to be effaced. When it was no longer visible in a diffused light, it was, unfortunately no longer visible when exposed directly to the sun. Perhaps I went badly to work, and very likely a more careful and delicate operator might have succeeded better. We might have explained in this way the effects of an extraordinary mirror mentioned by M. Ayrton, which, instead of reproducing the image engraved upon the reverse, disclosed to the astonished spectators the grotesque features of a Buddhist saint.

Brewster's theory, fortunately, was not known in France when public attention was directed upon magic mirrors. I say fortunately, because his opinion, being that of a celebrated man, might have led us astray. The first French physician who examined a magic mirror, Person, immediately discovered the true solution of the problem. In the first place, he found that the polished surface of the mirror was not perfectly convex, but only so in certain parts, corresponding with the lines of the figure upon the reverse. In the portions corresponding to the relief, it was almost flat. Rays of light reflected upon the convex parts diverge, and produce but a faint image. On the contrary, rays reflected upon the flat portions retain their parallelism, and produce an image which is very intense. This is why the ornaments in relief appear brilliant upon a dark background.

This irregularity of the surface depends of course upon the method of fabrication. When taken out of the cast, the mirror presents the appearance of a flat disk. Before being polished it is scratched in every sense of the word with a pointed instrument, to which it naturally offers more resistance in the thick parts than in the thin. This operation makes it at first slightly concave, and by the elastic reaction of the metal it becomes convex. This convexity is more sensible in the thin places than in those corresponding to the relief of the design. The mirror is finally polished with a whet-stone, then with charcoal, which must frequently destroy the irregularities which produce the magical effect. The surface thus becomes perfectly smooth, but generally one or two cavities can be found. The manufacturer fills these in with balls of copper which he has ready prepared and of all dimensions, and which he afterwards rubs and polishes until he thinks they are invisible to the naked eye. An expectation, however, which is but imperfectly realized, generally speaking. The entire surface is then rubbed by hand with an amalgam composed of equal portions of mercury and tin.

Such are the details of the manufacture of magic mirrors. It is easy to see that they quite agree with Person's explanation, but the latter has one objection. How, it will be asked, can the surface of the mirror be irregular without this being apparent in the images it reflects in a diffused light?

However, this objection is removed when we come to consider the facts attentively.

A mirror with a perfectly regular surface is an exceedingly rare object. Here, for instance, is a flat, metallic mirror employed in astronomical observations. The reflections it gives are very good.

Here also is a silver plaque which reflects in a manner equally perfect. If however, it is made to reflect an electric light, we can see clearly that the surface is not uniform, for we are able to perceive, so to speak, every blow of the hammer which it received during the process of manufacture. Here is one of those little round mirrors which we buy for a few pennies at the bazaars. It is excellent and extremely serviceable if you desire to comb your beard, but detestable if you wish it to reflect light.

By means of these examples you can easily see that all our common mirrors are irregular and reflect light imperfectly, although forms can be reflected by them very well. These are true magic mirrors, only the image reflected is as irregular as the mirror itself, while that of the Japanese mirror is regular like the curves of the surface which produces it.

But are we quite certain that the flat and the convex parts of an irregular mirror reflect a sufficiently variable amount of light to make them quite distinct, one from the other. Let us see:

Here is a convex mirror, the summit of which has been planed off, making a flat mirror in the middle of a convex one. I will now reflect it upon the the screen by means of an electric light. You see the central portion is a very brilliant disk which shows that the flat mirror reflects the cylindric portion. Around it is a black circle in which there is no light at all. This is the space between the cylinder and a sort of funnel which contains the light reflected by the convex mirror. This light forms around the black circle a grayish ring of feeble intensity and quite distinguishable from the white central disk. The difference would be much more marked if the two lights were closer together.

Here I have another mirror which is flat. To the middle of it has been attached a convex lens. The whole has then been silvered. A reflecting light you see, shows us upon the screen, a large spot nearly black surrounded by a brilliant ring which has another ring around it of a gray color. The centre and the rings about it are produced by the reflection upon the central convex lens, across which comes the cylinder formed by the reflection upon the flat mirror.

The variation in intensity of the two reflections is enormous, particularly in the centre, which only appears black by contrast. For, of course, there is just as much light upon the central disk as upon the edges. We know that it is really luminous for we can cast upon it the shadow of an opaque body.

It has been, I hope, clearly demonstrated to you, therefore, that the curves upon the surface of the mirror produce inequalities of marked intensity when reflected. You have, however, a perfect right to remain in doubt as to Person's theory, because in all magic mirrors, these irregularities are very faint, being almost invisible to the naked eye. Although Person has endeavored to sustain his theory by direct observations upon the surface of his mirror, it was necessary to support it still further by means of new experiments.

An Italian *savant*, M. Govi, has undertaken this task, and in 1864 and 1865 presented two papers upon the subject to the Academy of Turin.

The first one contains several experiments made for the purpose of upholding Person and utterly demolishing Brewster. But Brewster was determined not to give in, and after having translated M. Govi's article for the *Scientific Review*, he followed it up with a quantity of remarks and objections which he certainly never would have made had he ever been fortunate enough to hold a magic mirror in his hands.

The stupidity of the illustrious Scotch physician had a very good result, for it incited M. Govi to seek new proofs and obtain a surer ground than ever for his opinion. In this way he conceived the idea of making the most important and most curious experiment which had yet been seen in regard to metallic mirrors. He thought that by heating the mirrors on the back, the warmth would take effect sooner upon the thin parts than upon the thick; that the former would become more convex, and thus the magic property would increase in such mirrors as already possessed it in some degree, and might possibly be produced in those which were not magic.

Here is General Teissier's mirror—you have already seen that it was slightly magic—I shall now have it heated

by means of a gas light placed behind it, and you will immediately see that the magical effects become more intense. It develops by degrees and produces nearly all the forms and images which are on the back, quite perfectly. You observe that the great quantity of small figures which are in but slight relief are not visible, while all the others of pronounced relief are clearly brought out. This fact is an important one. It shows us that we must look for magic mirrors only among those having ornaments in decided relief upon their backs. You must also know that they are not to be found among very thick mirrors. The experiment is still more successful with this Japanese toilet mirror.

The first experiments, after reading M. Govi's papers, were made by M. Ayrton and myself, as we desired to verify the investigation of the Italian *savant* before publishing them, and at the same time study thoroughly this very interesting subject, hoping that we might be able, perhaps, to reproduce the mirror in France instead of importing them from the extreme East. You must bear in mind that we had but one mirror at our disposition and that one but slightly magic. It belonged to M. Dybowski. We began by heating it as I shall show you presently. Here is the natural mirror which is hardly magical at all. You see the effect is produced in proportion to the amount of heat employed. Heat applied to several other Japanese mirrors bought in Paris or borrowed from collectors produced a magical effect upon them all.

These experiments were repeated by us very often. But it was not long before we discovered the inconveniences of the heating method. First of all, as it is extremely difficult to preserve an equal degree of warmth upon the entire surface. The image is rarely perfectly regular; then the mirror itself is somewhat altered. The reverse becomes covered with a bronze iridescence while the surface loses its polish because the heat destroys the amalgam which covers it, the mirror loaned to me was in a frightful condition when I returned it,but it was finally put in order again. The spots upon the back were removed by a coating of slightly acidulated water, and the amalgamation replaced by nickel plating which made a more perfect and durable polish. Before giving it back to its owner, however, we had numerous copies made from it, and it was one of these which I showed you a few moments since.

The disadvantages of heating made us wonder if the same effect could not be produced by a different method, and we thought of pressure. M. Duboscq solved the problem by means of this box. You see it is not thick, and is of the precise diameter of the mirror which is attached to the upper part by an iron ring and one of India rubber. The under portion is closed and provided with a spout and plug which it connects with the little hand pump well known as the Gay-Lussac. This pump inhales on one side, and exhales on the other. If we attach an India rubber tube to the spout, on the exhaling side the movement of the piston will compress the air behind the mirror. We will now try it.

The mirror becomes more convex and the image widens. The thin portions protrude more than the others and the magical effect grows more and more pronounced. It will be quite complete when the pressure attains two atmospheres. We have it now! You see, the effect is perfect. It is certainly much finer than anything M. Ayrton has shown us, although his experiments astonished us so much.

We can also produce an inverse effect, by attaching the rubber tube to the inhaling spout. The action of the pump will remove the air beneath the mirror, which will become less convex and you see the luminous disk contract. The thin portions corresponding to the outlines of the design will yield more than the others, become less convex and perhaps concave. They will reflect more light and we may see a new image appear which will be the exact reverse of the preceding. That is to say, that the parts in relief will appear black upon a white ground. This is a *negative* form of the first, in which we saw the relief traced in white upon a black surface.

M. Deboscq made many other experiments, one of which I will relate to you before I conclude.

I wished to go still further. I wished to have a cast taken of the mirror while it is magic, and make a galvano-plastic deposit in the mould so that we might have a magic surface instead of a mirror. We tried this three times. The plaster moulding was very successful and the surface magic, but the galvano-plastic deposit was a complete failure. If any one here among my audience can give me any advice upon the subject I would be most grateful.

Gentlemen, I hope sincerely I have been able to interest you in this new subject of magic mirrors. If I have succeeded in making my meaning throughout, clear to you, these mirrors will no longer be a mystery, and you will have seen once more how Science, by slow but sure efforts, is finally able to explain and reproduce phenomena, which at first sight seemed miracles, always provided that the phenomena are real and not mere phantoms of human credulity.

RECENT SURGICAL CASE.

The following case, which, in some respects, is similar to that of President Garfield's, may be read with interest for the purpose of comparison. The man was sent to St. Michael's Hospital, Newark, N. J., where his case was considered hopeless at the date of his entry. We are indebted to Dr. H. C. H. Herold for a copy of the following report:

George Freund, age 36, Germany, ex-policeman.—Admitted to hospital July 4th, suffering from bullet wound of chest. The wound was produced by a 22-inch calibre pistol, and situated an inch and three-quarters below and half an inch to the left of the left nipple. When seen half an hour after admission his pulse, temperature and respiration were all normal. On examining his lungs the percussion note was normal. On auscultation, rales were heard over both lungs, resulting from chronic bronchitis. He is subject to attacks of asthma. Heart sounds normal. Ordered one-quarter of a grain of morphine every two hours until sleep was obtained.

July 5.—Morning. Passed a very restless night, not seeming to feel the effects of the morphine. Temperature, 102; pulse, 120; respiration, 32, and very labored. It was ascertained on examination that he was suffering from an asthmatic attack. He has had no spitting of blood and no sign of any lung trouble. Ordered grains x of iodide of potash, three times a day. July 5.—Evening. Complains of great pain in the vicinity of the wound, extending toward the stomach. Temperature, 102; skin feeling to the hand cold and covered with a clammy sweat. Pulse, 80; quite feeble and compressible, intermitting at every second beat. Respiration, 30; not labored, having recovered from his asthmatic attack.

July 6.—Passed a very restless night; one-eighth grain of morphia given every two hours; temperature, 103; pulse, 110; respiration, 40; labored and sighing; slight hemorrhage from wound; all pain left him.

July 7.—Passed a quiet night, sleeping very well; only one-eighth grain of morphia administered; temperature, 101; pulse, 106; respiration, 18; slight hemorrhage from wound; expectoration of a sputa which looks very much like laudable pus.

July 8,—Slept quite well, taking one-eighth grain of morphia; complains of some pain in vicinity of wound; hemorrhage from wound ceased; has taken no food since admission, being sustained by stimulants, beef tea, milk, etc.; temperature, 102; pulse, 115, quite strong, intermitting at every fifth beat; respiration, 26.

July 9.—Very comfortable night, taking only one-

eighth grain of morphia; wound discharging laudable pus; temperature, 101½; pulse, 110; respiration, 24.

July 10.—Restless night, no morphia being given. Wound still discharging healthy pus. Temperature, 101½; pulse, 110; respiration, 26.

July 11.—Temperature, 101; pulse, 110; respiration, 24.

July 12.—Temperature, 102; pulse, 110; respiration, 22. Ordered digitalis.

July 13.—Temperature, 100½; pulse, 100; respiration, 22. Urine containing traces of albumen. Solid food taken and retained.

July 14.—Temperature, 101; pulse, 108; respiration, 20.

July 15.—Temperature, 100½; pulse, 95; respiration, 22.

July 16.—Temperature, 100½; pulse, 100; respiration, 22.

July 17.—Temperature, 101; pulse, 100; respiration, 23.

July 18.—Temperature, 101; pulse, 100; respiration, 22.

July 19.—Very restless night. Temperature, 101½; pulse, 130; respiration, 34. Complains of pain in the region of the heart.

July 20.— Temperature 101½; pulse, 120; respiration, 34.

July 21.—Temperature, 101; pulse, 112; respiration, 32.

July 23.—Restless night, troubled much by a short, hacking cough; wound entirely healed, Temperature, 100¾; pulse, 106; respiration, 32. Vomited his breakfast.

July 24.—Passed a restless night notwithstanding the free use of bromide. Temperature, 103; pulse, 130; respiration, 38. Still troubled with cough, which distresses him greatly; cannot retain solid food. Stimulants freely given.

July 25.—Slept better, but cough still troubles him; breathing labored. Temperature, 100¾; pulse, 65; respiration, 39; muscular twitching of hands and feet.

July 26.—Much more comfortable this morning. Temperature, 100½; pulse, 92; respiration, 40; digitalis discontinued.

July 27.—Temperature, 99; pulse, 58; respiration. 36.

July 28.—Temperature, 98½; pulse, 56; respiration, 30.

July 29.—Temperature, 99; pulse. 60; respiration. 32.

July 30.—Delirious during the night, attempted to get out of bed. Temperature, 99½; pulse, 52; strong and full; respiration, 28.

July 31.—Temperature 99½; pulse, 68; respiration, 32. Delirious during night. Bromides given freely.

August 1.—Temperature, 100; pulse, 52; strong and full; respiration, 34.

August 2.—Temperature, 98½; pulse, 51; respiration. 30. Delirious during night.

August 3.—Temperature, 98½; pulse, 108; respiration, 22. Troubled very much with attacks of coughing.

August 4.—Temperature, 98½; pulse, 100; respiration, 24.

August 5.—Temperature, 98½; pulse, 96; respiration, 24.

August 6.—Temperature, 100; pulse, 96; respiration, 20.

August 7.—Temperature, 99; pulse 94; respiration 19.

August 8—Temperature, 98¾; pulse, 88; respiration, 22; sleeps well; appetite, good.

August 9.—Temperature, 98½; pulse, 90; respiration, 20.

August 13.—Temperature, pulse and respiration have remained the same as on August 9. The patient for the first time to-day since his injury has been allowed to get up and dress.

August 18.—Doing well since last report. Walks around the wards; eats and sleeps well, the bullet remaining in his body.

ON THE GERM THEORY.*

By Prof. Pasteur.

"The subject of my communication is vaccination in relation to chicken cholera and splenic fever, and a statement of the method by which we have arrived at these results—a method the fruitfulness of which inspires me with boundless anticipations. Before discussing the question of splenic fever vaccine, which is the most important, permit me to recall the results of my investigations of chicken cholera. It is through this inquiry that new and highly important principles have been introduced into science concerning the virus or contagious quality of transmissible diseases. More than once in what I am about to say I shall employ the expression virus-culture, as formerly, in my investigations on fermentation, I used the expressions, the culture of milk ferment, the culture of the butyric vibrion, etc. Let us take, then, a fowl which is about to die of chicken cholera, and let us dip the end of a delicate glass rod in the blood of the fowl with the usual precautions, upon which I need not here dwell. Let us then touch with this charged point some *bouillon de poule*, very clear, but first of all rendered sterile under a temperature of about 115° centigrade, and under conditions in which neither the outer air nor the vases employed can introduce exterior germs—those germs which are in the air, or on the surface of all objects. In a short time, if the little culture vase is placed in a temperature of 25° to 35°, you will see the liquid become turbid and full of tiny microbes, shaped like the figure 8, but often so small that under a high magnifying power they appear like points. Take from this vase a drop as small as you please, no more than can be carried on the point of a glass rod as sharp as a needle, and touch with this point a fresh quantity of sterilized *bouillon de poule* placed in a second vase, and the same phenomenon is produced. You deal in the same way with a third culture vase, with a fourth, and so on to a hundred, or even a thousand, and invariably within a few hours the culture liquid becomes turbid and filled with the same minute organisms.

"At the end of two or three days' exposure to a temperature of about 30° C. the thickness of the liquid disappears, and a sediment is formed at the bottom of the vase. This signifies that the development of the minute organism has ceased—in other words, all the little points which caused the turbid appearance of the liquid have fallen to the bottom of the vase, and things will remain in this condition for a longer or shorter time, for months even, without even the liquid or the deposit undergoing any visible modification, inasmuch as we have taken care to exclude the germs of the atmosphere. A little stopper of cotton sifts the air which enters or issues from the vase through changes of temperature. Let us take one of our series of culture preparations—the hundredth or the thousandth, for instance—and compare it in respect to its virulence with the blood of a fowl which has died of cholera; in other words, let us inoculate under the skin ten fowls, for instance, each separately with a tiny drop of infectious blood, and ten others with a similar quantity of the liquid in which the deposit has first been shaken up. Strange to say, the latter ten fowls will die as quickly and with the same symptoms as the former ten; the blood of all will be found to contain after death the same minute infectious organisms. This equality, so to speak, in the virulence both of the culture preparation and of the blood is due to an apparently futile circumstance. I have made a hundred culture preparations—at least, I have understood that this was done—without leaving any considerable interval between

* "International Medical Congress." London, 1881.

the impregnations. Well, here we have the cause of the equality in the virulence.

"Let us now repeat exactly our successive cultures with this single difference, that we pass from one culture to that which follows it—from the hundredth to, say, the hundred and first, at intervals, of a fortnight, a month, two months, three months or ten months. If, now, we compare the virulence of the successive cultures, a great change will be observed. It will be readily seen from an inoculation of a series of ten fowls that the virulence of one culture differs from that of the blood and from that of a preceding culture when a sufficiently long interval elapses between the impregnation of one culture with the microbe of the preceding. More than that, we may recognize by this mode of observation that it is possible to prepare cultures of varying degrees of virulence. One preparation will kill eight fowls out of ten, another five out of ten, another one out of ten, and another none at all, although the microbe may still be cultivated. In fact, what is no less strange, if you take each of these cultures of attenuated virulence as a point of departure in the preparation of successive cultures and without appreciable interval in the impregnation, the whole series of these culures will reproduce the attenuated virulence of that which has served as the starting point. Similarly, where the virulence is null it produces no effect. How, then, it may be asked, are the effects of these attenuating virulences revealed in the fowls? They are revealed by a local disorder, by a morbid modification more or less profound in a muscle, if it is a muscle which has been inoculated with the virus. The muscle is filled with microbes which are easily recognized, because the attenuated microbes have almost the bulk, the form, and the appearance of the most virulent microbes.

"But why is not the local disorder followed by death? For the moment let us answer by a statement of facts. They are these: the local disorder ceases of itself more or less speedily, the microbe is absorbed and digested, if one may say so, and little by little the muscle regains its normal condition. Then the disease has disappeared. When we inoculate with the microbe, the virulence of which is null, there is not even local disorder, the *naturæ medicatrix* carries it off at once, and here, indeed, we see the influence of the resistance of life, since this microbe, the virulence of which is null, multiplies itself. A little farther, and we touch the principle of vaccination. When the fowls have been rendered sufficiently ill by the attenuated virus which the vital resistance has arrested in its development, they will, when inoculated with virulent virus, suffer no evil effects, or only effects of a passing character. In fact, they no longer die from the mortal virus, and for a time sufficiently long, which in some cases may exceed a year, chicken cholera cannot touch them, especially under the ordinary conditions of contagion which exist in fowl-houses. At this critical point of our manipulation—that is to say, in this interval of time which we have placed between two cultures, and which causes the attenuation—what occurs? I shall show you that in this interval the agent which intervenes is the oxygen of the air. Nothing more easily admits of proof. Let us produce a culture in a tube containing very little air, and close this tube with an enameller's lamp. The microbe in developing itself, will speedily take all the oxygen of the tube and of the liquid, after which it will be quite free from contact with oxygen. In this case it does not appear that the microbe becomes appreciably attenuated, even after a great lapse of time. The oxygen of the air, then, would seem to be a possible modifying agent of the virulence of the microbe of chicken cholera—that is to say, it may modify more or less facility of its development in the body of animals. May we not be here in presence of a general law applicable to all kinds of virus? What benefits may not be the result? We may hope to discover in this way the vaccine of all virulent diseases; and what is more natural than to begin our investigation of the vaccine of what we in French call charbon, what you in England call splenic fever, and what in Russia is known as the Siberian pest, and in Germany as the Milzbrand.

"In this new investigation I have had the assistance of two devoted young *savants*—MM. Chamberland and Roux. At the outset we were met by a difficulty. Among the inferior organisms, all do not resolve themselves into those corpuscle germs which I was the first to point out as one of the forms of their possible development. Many infectious microbes do not resolve themselves in their cultures into corpuscle germs. Such is equally the case with beer yeast which we do not see develop itself usually in breweries, for instance, except by a sort of scissiparity. One cell makes two or more, which form themselves in wreaths; the cells become detached, and the process recommences. In these cells real germs are not usually seen. The microbe of chicken-cholera and many others behave in this way, so much so that the cultures of this microbe, although they may last for months without losing their power of fresh cultivation, perish finally like beer yeast which has exhausted all its aliments. The anthracoid microbe in artificial cultures behaves very differently. In the blood of animals, as in cultures, it is found in translucid filaments more or less segmented. This blood or these cultures freely exposed to air, instead of continuing according to the first mode of generation, show at the end of forty-eight hours corpuscle germs distributed in series more or less regular along the filaments. All around these corpuscles matter is absorbed. as I have represented it formerly in one of the plates of my work on the diseases of silkworms. Little by little all connection between them disappears, and presently they are reduced to nothing more than germ dust.

"If you make these corpuscles germinate, the new culture reproduces the virulence peculiar to the thready form which has produced these corpuscles, and this result is seen even after a long exposure of these germs to contact with air. Recently we discovered them in pits in which animals dead of splenic fever had been buried for twelve years, and their culture was as virulent as that from the blood of an animal recently dead. Here I regret extremely to be obliged to shorten my remarks. I should have had much pleasure in demonstrating that the anthracoid germs in the earth of pits in which animals have been buried are brought to the surface by earth-worms, and that in this fact we may find the whole etiology of disease, inasmuch as the animals swallow these germs with their food. A great difficulty presents itself when we attempt to apply our method of attenuation by the oxygen of the air to the anthracoid microbes. The virulence establishing itself very quickly, often after twenty-four hours in an anthracoid germ which escapes the action of the air, it was impossible to think of discovering the vaccine of splenic fever in the conditions which had yielded that of chicken-cholera. But was there, after all, reason to be discouraged? Certainly not; in fact, if you observe closely, you will find that there is no real difference between the mode of the generation of the anthracoid germ by scission and that of chicken-cholera. We had therefore reason to hope that we might overcome the difficulty which stopped us by endeavoring to prevent the anthracoid microbe from producing corpuscle germs, and to keep it in this condition in contact with oxygen for days, and weeks, and months. The experiment fortunately succeeded.

"In the ineffective (*neutre*) *bouillon de poule* the anthracoid microbe is no longer cultivable at 45° C. Its culture, however, is easy at 42° or 43°, but in these conditions the microbe yields no spores. Consequently it is possible to maintain in contact with the pure air at 42° or 43° a *mycélienne* culture of bacteria entirely free of germs. Then appear the very remarkable results which follow. In a month or six weeks the culture dies—that

is to say, if one impregnates with it fresh *bouillon*, the latter is completely sterile. Up to that time life exists in the vase exposed to air and heat. If we examine the virulence of the culture at the end of two days, four days, six days, eight days, etc., it will be found that long before the death of the culture the microbe has lost all virulence, although still cultivable. Before this period it is found that the culture presents a series of attenuated virulences. Everything is similar to what happens in respect to the microbe in chicken cholera. Besides, each of these conditions of attenuated virulence may be reproduced by culture ; in fact, since the charbon does not operate a second time (*ne récidive pas*), each of our attenuated anthracoid microbes constitutes for the superior microbe a vaccine—that is to say, a virus capable of producing a milder disease. Here, then, we have a method of preparing the vaccine of splenic fever. You will see presently the practical importance of this result, but what interests us more particularly is to observe that we have here a proof that we are in possession of a general method of preparing virus vaccine based upon the action of the oxygen and the air—that is to say, of a cosmic force existing everywhere on the surface of the globe.

"I regret to be unable, from want of time, to show you that all these attenuated forms of virus may very easily, by a physiological artifice, be made to recover their original maximum virulence. The method I have just explained of obtaining the vaccine of splenic fever was no sooner made known than it was very extensively employed to prevent the splenic affection. In France we lose every year, by splenic fever, animals of the value of twenty million francs. I was asked to give a public demonstration of the results already mentioned. This experiment I may relate in a few words. Fifty sheep were placed at my disposition, of which twenty-five were vaccinated. A fortnight afterward the fifty sheep were inoculated with the most virulent anthracoid microbe. The twenty-five vaccinated sheep resisted the infection ; the twenty-five unvaccinated died of splenic fever within fifty hours. Since that time my energies have been taxed to meet the demands of farmers for supplies of this vaccine. In the space of fifteen days we have vaccinated in the departments surrounding Paris more than twenty thousand sheep, and a large number of cattle and horses. If I were not pressed for time I would bring to your notice two other kinds of virus attenuated by similar means. These experiments will be communicated by-and-by to the public. I cannot conclude, gentlemen, without expressing the great pleasure I feel at the thought that it is as a member of an international medical congress assembled in England that I make known the most recent results of vaccination upon a disease more terrible, perhaps, for domestic animals than small-pox is for man. I have given to vaccination an extension which science, I hope, will accept as a homage paid to the merit and to the immense services rendered by one of the greatest men of England, Jenner. What a pleasure for me to do honor to this immortal name in this noble and hospitable city of London !"

FROM a privately issued report on silk cultivation in the Chinese province of Kwangtung, we learn that in the Pakhoi district, on the southern seaboard, wild silkworms are found which feed on the camphor tree, and their silk is utilized in a singular manner. When the caterpillar has attained its full size, and is about to enter the *pupa* state, it is cut open and the silk extracted in a form much resembling catgut. This substance, having undergone a process of hardening, makes excellent fish line, and is generally used for that purpose in the Pakhoi district.

CORRESPONDENCE.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

To the Editor of "SCIENCE."

Mr. Samuel J. Wallace, commenting on my paper on "The Use of Water as a Fuel" ("SCIENCE," Vol. II., p. 321), in an interesting communication to you ("SCIENCE," Vol. II., p. 373), suggests an inadvertancy on my part in "not more clearly distinguishing between the degrees of temperature at which the transfer of oxygen takes place from the hydrogen of the water to the carbon set free by the dissociation of the naphtha and the number of heat units set free or absorbed by such transfer, which is a very different thing."

To this I would state in reply that I have purposely refrained from an elaborate calculation of the thermal effects in heat units for several reasons. Of these I shall detail but a few of the more important at present.

In the first place, my intention was to give the scientific rationale of the chemical processes involved in the generation of the tremendous heat produced by the Holland retort with so insignificant an amount of naphtha ; and, furthermore, I wanted to show that the application of the principle of the correlation of forces and conservation of energy to this new and original process of combustion has been undertaken heretofore on an erroneous assumption ; lastly, I intended to prove, in the shortest and clearest possible manner, what a proportion of heat was gained, and in what manner—viz., by the dissociation of steam in the presence and by the agency of the carbon contained in the naphtha.

For these and other reasons, I avoided long explanations and calculations of other points, such as, for instance, the "dissociation of the naphtha," as Mr. Wallace puts it, and the figuring up of the heat units generated by the several elements on combustion. In order to re-affirm my position, which is, on most points, not that assumed by Mr. Wallace, I may be allowed to offer the following remarks :

It is self-evident that the carbon of the naphtha, in order to act independently, must first be set free ; this is accomplished by the heating of the naphtha, in its chamber of the retort, up to the point of gasification. On meeting the steam in the manifold, the carbon of the naphtha leaves its hydrogen and forthwith unites with the oxygen of the watery vapor, forming *either* carbonic oxide *or* carbonic acid, according to the amount of steam introduced.

Thus there is certainly a decomposition of the naphtha into its elements, as Mr. Wallace intimates ; but by far the most important process is the *dissociation of the watery vapor* which Mr. Wallace refuses to recognize, insisting, as he does, that there is only a *transfer* of the oxygen from the hydrogen of the steam to the carbon of the naphtha. How this is possible, without the previous dissociation of the steam, I am unable to understand. Mr. Wallace furnishes, indeed, the best argument against his own statement, by mentioning the well-known fact that the carbon in the naphtha is very loosely held by its hydrogen. But it is also a well-known fact that the oxygen of the steam is very tenaciously held by its hydrogen, so much so that it was considered impossible to separate, *to dissociate*, them by heat for a long time. Not until the late Henri St. Clair Deville * devised an appa-

* It is with profound grief that the announcement of the great chemist's death has been received everywhere. At his funeral (July 5th) M. Pasteur made an eloquent speech. The London *Chemical News* has an obituary in which occurs the following passage: "His highest achievement, from a strictly scientific point of view, was the establishment of the laws of dissociation. Previously, decomposition was regarded as a simple phenomenon, effected and completed, in the case of every substance, at a fixed temperature. Deville showed that in some cases it is effected within certain limits of temperature, being arrested at a given heat by the equilibrium established between the decomposing body and the product of decomposition."

ratus *for this purpose* was this dissociation accomplished by heat alone.

The reason for this state of things is apparent. Hydrogen in uniting with oxygen to form water develops the greatest amount of heat, a greater amount, in fact, than an equal weight of any other known element. And just here I would ask Mr. Wallace which authority has stated that the "absolute heat of carbon and hydrogen are almost exactly equal in complete burning." On the contrary, all authorities agree, and all investigators have established beyond doubt the fact, that hydrogen develops *more than four times as much heat* on combustion than does an equal weight of carbon. The figures at present universally accepted as a standard are those determined by Favre and Silberman, during their carefully conducted and numerous experiments. According to them—

1 grain of hydrogen develops 34,462 units of heat.
1 grain of carbon " 8,080 units of heat.

on complete combustion.

This great advantage in the heat-producing power of hydrogen is the principal reason why scientists have constantly striven to substitute this element for carbon, which is now universally used as fuel. But until lately only this was thought impracticable, because it was believed that the same amount of heat was necessary to obtain the hydrogen by the dissociation of water, which would ultimately be obtained by the combustion of said hydrogen. And even the processes of Strong and others for the generation of so-called 'water-gas' have not changed this erroneous view. For, the advantages arrived at by them were ascribed rather to various extraneous causes* than to the one principal cause, *i. e.*, the dissociation of steam by the chemical affinity of carbon, and the consequent generation of a not inconsiderable amount of hydrogen.

This very same line of argument has been followed in the discussions about the Holland process, and the principal aim of my paper was to controvert it, and to show that it is *not heat, but chemical affinity*, which does by far the greatest part of the work of dissociation. I was enabled to do so on the basis of Dahlerus' experiments, which have proved conclusively that carbon will dissociate water at 400° C, instead of 8000° C, which is Deville's figure for the dissociation-temperature of water in the absence of any other element.†

From the foregoing the readers of "SCIENCE" will perceive that the enormous gain obtained by actual experiment with the Holland locomotive is satisfactorily explained on scientific grounds.

All the further argumentation of Mr. Wallace covers the earlier water-gas processes of Lowe, Strong and others; they generate their gaseous fuel in a separate contrivance (the generator) and afterward burn it. For this reason they want to accomplish only the first stage of carbon, combustion water-gas, consisting of hydrogen and carbonic oxide. In the process under consideration, however, the retort which prepares the fuel, *i. e.*, gasifies the naphtha and the water, is placed just where the heating is to take place. All the heat, therefore, that is developed by the carbon combustion is utilized, as is also all the heat which is developed by the dissociated hydrogen burning up with atmospheric oxygen.

Indeed, this process is the only one which comes pretty near to fulfill all the requirements of an ideal method. These are;

1. Gaseous condition of the fuel.
2. Complete combustion (no smoke, no ashes).
3. Full effects of the caloric energy developed.
4. Regulation of the draught-air, so as to admit the least amount of atmospheric air practicable.
5. Greatest possible percentage of oxygen in atmosphere of combustion. (The oxygen derived from the dissociation of the steam being employed for the combustion of carbon, the necessary draught-air is thereby materially reduced and thus the percentage of oxygen increased).
6. Universal adaptibility (kitchen and parlor stoves, fire places, stationary and other boilers, locomotives and ocean steamers can be accommodated with it, and illuminating gas is prepared automatically by an additional chamber in the retort).
7. Simplicity of apparatus. (May be managed by the turning of a few faucets.)
8. Cheapness of the fuel employed. (Water is certainly to be obtained everywhere at small expense, while the price of naphtha is only three cents a gallon if bought by the single barrel.)
9. Fuel used of the greatest heating capacity, with each atom of Carbon burned, there are burned at the same time *four* atoms of Hydrogen, thus:

$$\underset{\text{(Naphtha.)}}{C_2H_4} + \underset{\text{(Water.)}}{4\,HO} = 2\,(CO_2) + 8\,H.$$

The eight Hydrogen are burned with atmospheric Oxygen.

Crude oil *i. e.* petroleum that has undergone one distillation, to free it from its mineral and waxy ingredients, may be used, but would be much dearer. Naphtha, it may be said in conclusion, is not one of the distillation products, as might be inferred from the name: It is the unused residue from all the various distillation-processes to which petroleum is subjected. *It is a waste product* and therefore cheaper than anything else.

It is obtained in this wise:

The crude oil as it is received from the stills of the petroleum regions is subjected to twelve successive distillations, and the following products result:

Cymogene.
Rhigolene.
Gasolene.
C. Naphtha.
B. Naphtha.
A. Naphtha.
Benzine.
Kerosene.
Mineral Sperm Oil.
Lubricating Oil.
Paraffin.

Of these only the last four are completely used in the arts and for illuminating purposes. The unused residue of all the others is thrown back into the residue remaining from the last distillation. The quality of the mixture called Naphtha, and used in the Holland process is therefore not always the same, but this does not at all alter its value as a fuel, as it does not alter the main features of this process, as they have been explained in our remarks.

GEO. W. RACHEL, M. D.

* Some of these are: gasification of the fuel, substitution of the second for the first stage of carbon—combustion, reduction of the amount of draft-air, etc.

† The combustion- (and dissociation-) temperature may be found by calculation from the thermal effect and the specific heat of the product (*i. e.*, water) in the following manner, according to MOHR (Mech. Theorie d. chem. Affin., p. 102):

If one part of hydrogen burns up with eight parts of oxygen, forming nine parts of water, 34462 units of heat are generated which are contained in the watery vapor thus formed. If the specific heat of steam would be the same as that of water, the actual temperature of these nine parts of water would be:

$$\frac{34462}{9} = 38290°\ C.$$

Since the specific heat of steam is, however: .475, the actual temperature of the nine parts of watery vapor is:

$$\frac{3829}{.475} = 8061°\ C.$$

For this reason 8000° C has been assumed as the dissociation-temperature of watery vapor.

King's Cross Station, Great Northern Railway, is now lighted by means of electricity, a beginning having been made last week by means of the Crompton system. There are 12 Crompton lamps within the station, six being placed over the arrival, and a similar number over the departure platform. Two other lamps of larger size are placed outside the station building. The interior area lighted consists of two bays, each 880 feet long and 105 feet wide, and 72 feet high, as well as the cab-rank adjoining the arrival platform, which is 40 feet wide. The total area lighted is 220,000 square feet, giving an area of 18,133 square feet, or nearly half an acre, to each lamp. The lamps are suspended at a height of 30 feet from the platform level, and are arranged on four circuits, the light of each lamp being computed as equivalent to 4000 candles. Any unpleasantness from the intensity of the light is obviated by the use of semi-transparent glass in the lower portion of the lanterns. The two exterior lights are estimated at 6000 candles each, are placed at an altitude of 70 feet, the lanterns being of clear glass. The current is supplied by means of five Burgin dynamo-electric machines, which are driven by a semiportable engine by Messrs. Marshall, Sons & Co., of Gainsborough, working up to 35-horse power.

THE death of John Duncan, the Alford, England, botanist, is announced as having taken place last week in his 85th year. The deceased adopted the occupation of a weaver by trade, but devoted all his spare time to the study of botany. His splendid collection of plants he handed over to Aberdeen University a year ago, but he has lived barely six months to enjoy the fund which public recognition of his merits placed at his disposal in his declining years. The story of John Duncan's life is to be told by Mr. Jolly, himself an enthusiastic botanist.

Various attempts have been made to explain the tails of comets. A recent one by M. Picart is as follows: The Sun, the stars, nebulæ and comets, are composed not only of ponderable matter in the gaseous state, but of imponderable matter, the luminous ether, revealed, in the case of the sun by the zodiacal light, and in that of nebulæ, by their irregular forms contrary to gravitation. A comet far from the sun, appears in spheroidal form, due to gravitation of its ponderable matter (its luminous ether being then invisible because of distance and feeble light). But on nearing the sun, the luminous ether of this body repels that of the comet (this being a characteristic property of the ether) so forming the tail. The form and direction of the tail are thus quite independent of gravitation; and the enormous velocity ceases to be a difficulty, as it is if the matter of the tail be thought ponderable. M. Lamey has observed that the solar light, being unable completely to penetrate the comet's tail, illumines only the left part, producing a true cometary phase.

THE assimilation of nitrogen by plants has, of late, been carefully studied by Signor Lamattina, of Rome, who arrives at the following results: Plants absolutely require to assimilate nitrogen, and they obtain it in three forms: (1) In the nitrates of the ground; (2) In the ammonia of the air; (3) In the State of protoxide in the atmosphere. The nitrogen in the state of nitrates, absorbed by the roots, is for transport and diffusion of mineral substances, principally potash, in the leaves, helping to form chlorophyll and hydrocarbons. The nitrogen absorbed in the form of ammonia by respiration, serves for formation of albuminoids, fibrine, etc. The nitrogen absorbed in the state of protoxide, appears to serve as complement of the food of the plant, acting both as corrective, by neutralising the basis in excess, and helping in the formation of alkaloids.

METEOROLOGICAL REPORT FOR NEW YORK CITY FOR THE WEEK ENDING AUG. 27, 1881.

Latitude 40° 45′ 58″ N.; Longitude 73° 57′ 58″ W.; height of instruments above the ground, 53 feet; above the sea, 97 feet; by self-recording instruments.

AUGUST.	BAROMETER.					THERMOMETERS.											
	MEAN FOR THE DAY.	MAXIMUM.		MINIMUM.		MEAN.		MAXIMUM.				MINIMUM.				MAXI'M
	Reduced to Freezing.	Reduced to Freezing.	Time.	Reduced to Freezing.	Time.	Dry Bulb.	Wet Bulb.	Dry Bulb.	Time.	Wet Bulb.	Time.	Dry Bulb.	Time.	Wet Bulb.	Time.	In Sun.
Sunday, 21..	29.628	29.678	12 p. m.	29.598	5 p. m.	77.0	69.0	85	5 p. m.	73	5 p. m.	68	5 a. m.	65	5 a. m.	144.
Monday, 22..	29.802	29.896	12 p. m.	29.678	0 a. m.	74.0	66.0	81	3 p. m.	69	2 p. m.	67	12 p. m.	62	12 p. m.	139.
Tuesday, 23..	29.979	30.046	12 p. m.	29.896	0 a. m.	72.3	64.0	83	5 p. m.	69	2 p. m.	61	6 a. m.	59	6 a. m.	140.
Wednesday, 24..	30.138	30.196	12 p. m.	30.046	0 a. m.	73.3	66.6	82	2 p. m.	73	2 p. m.	63	5 a. m.	60	6 a. m.	141.
Thursday, 25..	30.200	30.212	9 a. m.	30.168	6 p. m.	70.3	64.6	76	3 p. m.	67	3 p. m.	65	3 a. m.	62	3 a. m.	131.
Friday, 26..	30.151	30.198	0 a. m.	30.110	4 p. m.	71.7	67.0	82	3 p. m.	73	3 p. m.	63	7 a. m.	62	8 a. m.	134.
Saturday, 27..	30.114	30.156	9 a. m.	30.072	6 p. m.	72.0	66.7	78	2 p. m.	70	2 p. m.	66	6 a. m.	64	6 a. m.	128.

Mean for the week .... 30.002 inches.
Maximum for the week at 9 a. m., August 25th .... 30.212 "
Minimum " at 5 p. m., August 21st .... 29.598 "
Range .... .614 "

	Dry.		Wet.	
Mean for the week	72.9	degrees	66.2	degrees.
Maximum for the week, at 5 pm. 21st	85.	" at 5 pm 21st,	73.	"
Minimum " " 6 am. 23d	61.	" at 6 am 23d,	59.	"
Range " "	24.	"	14.	"

AUGUST.	WIND.						HYGROMETER.						CLOUDS.			RAIN AND SNOW.				OZONE.
	DIRECTION.			VELOCITY IN MILES.	FORCE IN LBS. PER SQR. FEET.		FORCE OF VAPOR.			RELATIVE HUMIDITY.			CLEAR, 0 OVERCAST. 10			DEPTH OF RAIN AND SNOW IN INCHES.				
	7 a. m.	2 p. m.	9 p. m.	Distance for the Day.	Max.	Time.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	Time of Begining.	Time of Ending.	Duration. h. m.	Amount of water	
Sunday, 21.	n.	n. n. e.	w. n.w.	123	3¼	11 am	.537	.623	.652	71	53	73	3cir.cu.s	3 cu. s.	10	11 p m	11½ p m	0.30	.01	3
Monday, 22.	n. w.	n. w.	n. n. w.	153	3	3.30 pm	.516	.547	.537	70	52	71	0	3 cu.	0	-----	-----	-----	--	7
Tuesday, 23.	n. w.	n. w.	n. n. w.	155	2¼	4.40 pm	.433	.547	.489	72	52	62	0	3 cu.	0	-----	-----	-----	--	1
Wednesday, 24.	n. n. e.	n. e.	s. e.	121	4	1.30 pm	.462	.663	.564	65	63	79	0	1 cir. cu.	0	-----	-----	-----	--	0
Thursday, 25.	s. s. e.	s.	s. s. w.	140	2¼	3.20 pm	.509	.554	.543	74	64	79	8 cu.	0	0	-----	-----	-----	--	0
Friday, 26.	w. s. w.	s.	s. s. w.	150	2	3.00 pm	.576	.624	.608	100	59	80	10	1 cu.	0	-----	-----	-----	--	0
Saturday, 27.	s. w.	s.	s. s. w.	140	2	4.40 pm	.543	.625	.586	79	65	80	8 cu.	1 cu.	0	-----	-----	-----	--	0

Distance traveled during the week .... 982 miles.
Maximum force .... 4 lbs.

Total amount of water for the week .... .01 inch.
Duration of rain .... 00 hours, 30 minutes.

DANIEL DRAPER, Ph. D.
Director Meteorological Observatory of the Department of Public Parks, New York.